# SYSTEM AND METHOD FOR MONITORING AND CONTROLLING RESIDENTIAL DEVICES

## CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of U.S. patent applications Serial No. 09/271,517; filed March 18, 1999, and entitled, "System For Monitoring Conditions in a Residential Living Community;" No. 09/439,059, filed November 12, 1999, and entitled, "System and Method for Monitoring and Controlling Remote Devices," and Serial No. 09/102,178; filed June 22, 1998, entitled, "Multi-Function General Purpose Transceiver;" Serial No. 09/172,554; filed October 14, 1998, entitled, "System for Monitoring the Light Level Around an ATM;" Serial No. 09/412,895; filed October 5, 1999, entitled, "System and Method for Monitoring the Light Level Around an ATM. Each of the identified U.S. patent applications is incorporated herein by reference in its entirety. This application also claims the benefit of U.S. provisional application Serial No. 60/201,252, filed May 1, 2000, and entitled "System and Method for Monitoring and Controlling Remote Devices," the contents of which are hereby incorporated by reference.

## FIELD OF THE INVENTION

The present invention generally relates to remotely operated residential systems, and more particularly to a computerized system for monitoring, reporting, and controlling residential systems via a multiple access wide area network, a gateway, radio-frequency transceivers and repeaters, and software applications to appropriately process and direct various data and control signals.

## BACKGROUND OF THE INVENTION

As is known, there are a variety of systems for monitoring and controlling manufacturing processes, inventory systems, emergency control systems, and the like. Most automated systems use remote sensors and controllers to monitor and respond to various system parameters to reach desired results. A number of control systems utilize computers or dedicated microprocessors in association with appropriate software to

process system inputs, model system responses, and control actuators to implement corrections within a system.

One way to classify control systems is by the timing involved between subsequent monitoring occurrences. Control systems can be classified as aperiodic or random, periodic, and real-time. A number of remotely distributed service industries implement the monitoring and controlling process steps through manual inspection and intervention.

Aperiodic manual monitoring systems (those that do not operate on a predetermined cycle) are inherently inefficient as they require a service technician to physically traverse an area to record data, repair out of order equipment, add inventory to a vending machine, and the like. Such service trips are carried out in a number of industries with the associated costs being transferred to the consumers of the service.

Conversely, utility meter monitoring, recording, and client billing are representative of discrete steps in a periodic monitoring system. In the past, utility providers sent a technician from meter to meter on a periodic basis to verify meter operation and to record utility use. One method of cutting utility meter reading operating expenses involved increasing the period at which manual monitoring and meter data recording was performed. While this modified method decreased the monitoring and recording expense associated with more frequent meter observation and was convenient for consumers who favor the consistent billed amounts associated with "budget billing," the utility provider retained the costs associated with less frequent meter readings and the processing costs associated with reconciling consumer accounts.

Lastly, a number of environmental and safety systems require constant or real-time monitoring. Heating, ventilation, and air-conditioning (HVAC) systems, fire reporting and damage control systems, alarm systems, and access control systems are representative systems that utilize real-time monitoring and often require immediate feedback and control. These real-time systems have been the target of control system theory and application for some time.

Home automation systems may comprise control systems that exemplify all three periodicity variations. For example, a remote command designed to turn on interior lights may be classified as aperiodic or random. Whereas, it may be desirable to send periodic

control signals to a landscape lighting system, pet feeders, irrigation systems, *etc*. Finally, security systems, smoke detectors, and related fire prevention systems exemplify household systems in need of real-time monitoring and control.

Various schemes have been proposed to facilitate inter-device communications between closely located devices, including radio-frequency (RF) transmission, light transmission (including infra-red), and control signal modulation over the local power distribution network. For example, U.S. Patent No. 4,697,166 to Warnagiris *et al.* describes a power-line carrier backbone for inter-element communications. As recognized in U.S. Patent No. 5,471,190 to Zimmerman, there is a growing interest in home automation systems and products that facilitate such systems. One system, critically described in the Zimmerman patent, is the X-10 system. Recognizing that consumers will soon demand interoperability between household systems, appliances, and computing devices, the Electronics Industry Association (EIA) has adopted an industry standard, known as the Consumer Electronics Bus (CEBus). The CEBus is designed to provide reliable communications between suitably configured residential devices through a multi-transmission media approach within a single residence.

One problem with expanding the use of control systems technology to distributed systems is the cost associated with the necessary build-out of the local sensor - actuator infrastructure necessary to interconnect the various devices. A typical approach to implementing control system technology is to install a local network of hard-wired sensors and actuators along with a local controller. Not only is there expense associated with developing and installing appropriate sensors and actuators but the added expense of connecting functional sensors and actuators with the local controller. Another prohibitive cost associated with applying control systems technology to distributed systems is the installation and operational expense associated with programming the local controller.

Accordingly, an alternative solution for implementing a distributed control system suitable for home automation that overcomes the shortcomings of the prior art is desired.

## SUMMARY OF THE INVENTION

Certain objects, advantages and novel features of the invention will be set forth in part in the description that follows and in part will become apparent to those skilled in the art upon examination of the following or may be learned with the practice of the invention. The objects and advantages of the invention may be realized and obtained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

To achieve the advantages and novel features, the present invention is generally directed to a system and a cost-effective method for monitoring and controlling home automation devices remotely via a distributed wide-area network (WAN). More specifically, the present invention is directed to a computerized system for monitoring, reporting, and controlling household related systems and system information via WAN gateway interfaces. The various user applications may be found on one or more applications servers in communication with the WAN. Each of the input and output signals to and from the various household devices may be communicated via appropriately configured RF transceivers and repeaters (where required) in communication with WAN gateways. In preferred embodiments of the network infrastructure, database servers in communication with the WAN store identification information related to each of the various transceivers along with appropriate codes suitable for a related application. Because the applications server is integrated on a WAN, Web browsers can be used by anyone with WAN access (and the appropriate software access permissions) to view and download the recorded data, as well as, to customize particular home automation applications.

In accordance with a broad aspect of the invention, a system is provided having one or more sensors to be read and / or actuators to be controlled, ultimately through a computing device in communication with the WAN. The sensors and / or actuators are in communication with wireless transceivers that transmit and / or receive encoded data and control signals information to and from the computing device. In this regard, additional wireless repeaters may relay information between transceivers disposed in connection with the sensors and actuators and a gateway to the WAN. It should be appreciated that,

a portion of the information communicated includes data that uniquely identifies the sensors and / or actuators. Another portion of the data is a multi-bit code word that may be decipherable through a look-up table within either the WAN gateway or a WAN interconnected computer.

In accordance with one aspect of the invention, a system is configured to monitor and report system parameters. The system is implemented by using a plurality of wireless transceivers. At least one wireless transceiver is interfaced with a sensor, transducer, actuator or some other device associated with an application parameter of interest. In this regard, the term "parameter" is broadly construed and may include, but is not limited to, a system alarm condition, a system process variable, an operational condition, *etc*. The system also includes a plurality of transceivers that act as signal repeaters that are dispersed throughout the nearby geographic region at defined locations. By defined locations, it is meant only that the general location of each transceiver is "known" by a WAN integrated computer. WAN integrated computers may be informed of transceiver physical locations after permanent installation, as the installation location of the transceivers is not limited. Each transceiver that serves to repeat a previously generated data signal may be further integrated with its own unique sensor or a sensor actuator combination as required. Additional transceivers may be configured as stand-alone devices that serve to simply receive, format, and further transmit system data signals. Further, the system includes a local data formatter that is configured to receive information communicated from the transceivers, format the data, and forward the data via the gateway to one or more software application servers interconnected with the WAN. The application server further includes means for evaluating the received information and identifying the system parameter and the originating location of the parameter. The application server also includes means for updating a database or further processing the reported parameters.

Consistent with the broader concepts of the invention, the "means" for evaluating the received information and the "means" for reporting system parameters are not limited to a particular embodiment or configuration. Preferably, these "means" will be implemented in software that is executed by a processor within an application server

integrated with the public access WAN commonly known as the Internet. However, dedicated WANs or Intranets are suitable backbones for implementing defined system data transfer functions consistent with the invention.

In one embodiment, a client retrieves configured system data by accessing an Internet Web site. In such an embodiment, a system consistent with the present invention acts as a data collector and formatter with data being delivered upon client request twenty-four hours a day, seven days a week.

In more robust embodiments, a system can be configured to collect, format, and deliver client application specific information on a periodic basis to predetermined client nodes on the WAN. In these embodiments, client intervention would serve to close the feedback loop in the control system.

In yet another embodiment, a system can be configured to collect, format, and control client application specific processes by replacing a local controller (*e.g.*, a computer) with a WAN interfaced application server and integrating system specific actuators with the aforementioned system transceivers.

It should be further appreciated that the information transmitted and received by the wireless transceivers may be further integrated with other data transmission protocols for transmission across telecommunications and computer networks other than the Internet. In addition, it should be further appreciated that telecommunications and computer networks other than the Internet can function as a transmission path between the networked wireless transceivers, the local gateways, and the central server. For example, a gateway in accordance with the system and method of the present invention may be interconnected with the Internet via the PSTN, a CATV network, or other suitable network to bridge gaps in a distributed system network.

In yet a further embodiment, a system can be configured using the present invention to translate and transmit control signals from an existing local controller via the networked wireless transceivers. In this regard, a system consistent with the teachings of the present invention would require a data translator to tap into the data stream of an existing control system. Distinct control system signals may be mapped to function codes used by the present invention in order to provide customer access to control system data.

In this way, the system of the present invention can be integrated with present data collection and system controllers inexpensively, as customers will only have to add a data translator and a wireless transmitter or transceiver as the application demands. By integrating the present invention with a data stream generated by present monitoring and control systems, potential customers enjoy the benefits of the present invention without the difficulties associated with integrating sensors and actuators to monitor individual system parameters.

## BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings incorporated in and forming a part of the specification, illustrate several aspects of the present invention, and together with the description serve to explain the principles of the invention. The components in the drawings are not necessarily to scale, emphasis instead being placed upon clearly illustrating the principles of the present invention. Moreover, in the drawings, like reference numerals designate corresponding parts throughout the several views. In the drawings:

FIG. 1 is a block diagram of a prior art control system;

FIG. 2 is a schematic diagram illustrating a distributed data monitoring / control system suitable for home automation applications in accordance with the present invention;

FIG. 3 is a schematic illustrating multiple interface devices that can be used in a home automation control system application of FIG. 2;

FIGs. 4A through 4D are functional block diagrams illustrating various combinations of sensors, actuators, transmitters, and transceiver / repeaters that may be used with the home automation control system of FIGs. 2 and 3;

FIG. 5 is a functional block diagram that further illustrates the local WAN gateway of the control system of FIG. 2;

FIG. 6 is a table illustrating a message structure that may be used to communicate data and control signals via the various RF communication devices of FIGs. 4A through 4D in the control system of FIG. 2;

FIG. 7 is a diagram illustrating sample messages that may be communicated in the control system of FIG. 2;

FIG. 8 is a schematic diagram further illustrating the various WAN interconnected devices of the control system of FIG. 2;

FIG. 9 is a schematic diagram illustrating the implementation of a first client specific application using the control system of FIG. 2;

FIG. 10 is a schematic diagram illustrating a second client specific application using the control system of FIG. 2;

FIG. 11 is a block diagram illustrating how a WAN connected application server of FIG. 2 can be used to service multiple client residences; and

FIGs. 12A and 12B are exemplary diagrams illustrating a software interface that may be resident of the application server of FIG. 2.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Having summarized the invention above, reference is now made in detail to the description of the invention as illustrated in the drawings. While the invention will be described in connection with these drawings, there is no intent to limit it to the embodiment or embodiments disclosed therein. On the contrary, the intent is to cover all alternatives, modifications and equivalents included within the spirit and scope of the invention as defined by the appended claims.

Referring now to the drawings, reference is made to FIG. 1, which is a block diagram illustrating fundamental components of a prior art control system generally identified by reference numeral 1. More particularly, a prior art control system 1 includes a local controller 10 in communication with the public-switched telephone network (PSTN) 12 in further communication with a central controller / monitor 13. As is also illustrated in FIG. 1, the local controller may be in communication with a plurality of sensor / actuators 15. In a manner well known in the art of control systems, local controller 10 provides power, formats and applies data signals from each of the sensors to predetermined process control functions, and returns control signals as appropriate to the system actuators via the communicatively coupled sensor / actuators 15. Often, prior art

control systems are further integrated via the PSTN 12 to a central controller /monitor 13 as shown. The central controller / monitor 13 can be further configured to serve as a technician monitoring station or to forward alarm conditions via the PSTN 12 to appropriate public safety officers (not shown).

Prior art control systems consistent with the design of FIG. 1 require the development and installation of an application-specific local system controller, as well as, the routing of electrical conductors to each sensor and actuator as the application requires. Such prior art control systems are typically augmented with a central controller / monitor 13 that may be networked to the local controller 10 via a modem (not shown) and the PSTN 12. As a result, prior art control systems often consist of a relatively heavy design and are subject to a single point of failure should the local controller 10 go out of service. In addition, these systems require electrical coupling between the local controller 10 and system sensor / actuators 15. As a result, appropriately wiring an existing residential home can be an expensive proposition.



Reference is now made to FIG. 2, which is a schematic diagram illustrating a distributed data monitoring / control system suitable for home automation applications in accordance with the present invention. As illustrated in FIG. 2, a distributed data monitoring / control system (DDMCS) in accordance with the present invention is identified generally by reference numeral 100. The DDMCS 100 may comprise one or more application servers 160 (one shown for simplicity of illustration), one or more data base servers 170, a WAN 130, a plurality of transceiver / repeaters 111, sensor / actuators 112, transceivers 113, sensors 114, transmitters 115, and at least one local gateway 110. As is further illustrated in FIG. 2, each of the sensor / actuators 112 and sensors 114 is integrated such that it is communicatively coupled with a suitably configured RF transceiver / repeater 111, a RF transceiver 113, or a RF transmitter 115. Hereinafter, the group including a RF transceiver / repeater 111, a RF transceiver 113, and a RF transmitter 115 will be referred to as RF communication devices. Those skilled in the art will appreciate the application of the various devices deployed in a wireless network interface between a plurality of residential system sensors 114 and sensor / actuators 112

and various computing devices in communication with a WAN 130 in a distributed home automation control system.

Each of the aforementioned RF communication devices is preferably small in size and may be configured to transmit a relatively low-power RF signal. As a result, in some applications, the transmission range of a given RF communication device may be relatively limited. As will be appreciated from the description that follows, this relatively limited transmission range of the RF communication devices is an advantageous and desirable characteristic of the DDMCS 100. Although the RF communication devices are depicted without a user interface such as a keypad, in certain embodiments the RF communication devices may be configured with user selectable pushbuttons, switches, or an alphanumeric keypad suitably configured with software and or firmware to accept operator input. Often, the RF communication devices will be electrically interfaced with a sensor 114 or with a combination sensor / actuator 112, such as with a smoke detector, a thermostat, a security system, *etc.*, where user selectable inputs may not be needed.

As illustrated in FIG. 2, one or more sensors 114 may be communicatively coupled to at least one local gateway 110 via a RF transmitter 115, a RF transceiver 113, or in the alternative, a RF transceiver / repeater 111. Furthermore, one or more sensor / actuators 112 may be communicatively coupled to at least one local gateway 110 via a RF transceiver 113 or alternatively a RF transceiver / repeater 111. Those skilled in the art will appreciate that in order to send a command from the server 160 to a sensor / actuator 112, the RF device in communication with the sensor / actuator 112 should be a two-way communication device. It will also be appreciated that one or more sensor / actuators 112e may be in direct communication with one or more local gateways 110a, 110b. It will be further appreciated that the communication medium between the one or more sensor / actuators 112e and the one or more local gateways 110a, 110b may be wireless or for relatively closely located configurations a wired communication medium may be used.

As is further illustrated in FIG. 2, a DDMCS 100 in accordance with the teachings of the present invention may comprise a plurality of stand-alone RF transceiver / repeaters 111. Each stand-alone RF transceiver / repeater 111 as well as each RF transceiver 113

may be configured to receive one or more incoming RF transmissions (transmitted by a remote transmitter 115 or transceiver 113) and to transmit an outgoing signal. This outgoing signal may be another low-power RF transmission signal, a higher-power RF transmission signal, or alternatively may be transmitted over a conductive wire, fiber optic cable, or other transmission media. The internal architecture of the various RF communication devices will be discussed in more detail in connection with FIGs. 4A through 4D. It will be appreciated by those skilled in the art that integrated RF transceivers 113 can be replaced by RF transmitters 115 for client specific applications that require data collection only.

One or more local gateways 110a and 110b are configured and disposed to receive remote data transmissions from the various stand-alone RF transceiver / repeaters 111, integrated RF transmitters 115, or the integrated RF transceivers 113. The local gateways 110a and 110b may be configured to analyze the transmissions received, convert the transmissions into TCP/IP format and further communicate the remote data signal transmissions via WAN 130 to one or more application servers 160 or other WAN 130 interconnected computing devices. In this regard, and as will be further described below, local gateways 110a and 110b may communicate information in the form of data and control signals to remote sensor / actuators 112 and remote sensors 114 from application server 160, laptop computer 140, and workstation 150 across WAN 130. The application server 160 can be further associated with a database server 170 to record client specific data or to assist the application server 160 in deciphering a particular data transmission from a particular sensor 114.



It will be appreciated by those skilled in the art that if an integrated RF communication device (*e.g.*, a RF transmitter 115, a RF transceiver 113, or a RF transceiver / repeater 111) is located sufficiently close to local gateways 110a or 110b such that its RF output signal can be received by one or more local gateways 110, the data transmission signal need not be processed and repeated through either a RF transceiver / repeater 111 or a RF transceivers 113.

It will be further appreciated that a DDMCS 100 may be used in conjunction with a variety of residential systems to permit remote data access and control via a plurality of

distributed computing devices in communication with a suitable WAN 130. As will be further appreciated from the discussion herein, each of the RF communication devices may have substantially identical construction (particularly with regard to their internal electronics), which provides a cost-effective implementation at the system level. Furthermore, a plurality of stand-alone RF transceiver / repeaters 111, which may be identical to one another, may be disposed in such a way that adequate coverage throughout a residence and or a residential community is provided. Preferably, stand-alone RF transceiver / repeaters 111 may be located such that only one stand-alone RF transceiver / repeater 111 will pick up a data transmission from a given integrated RF transceiver 113 and or RF transmitter 115. However, in certain instances two or more stand-alone RF transceiver / repeaters 111 may pick up a single data transmission. Thus, the local gateways 110a and 110b may receive multiple versions of the same data transmission signal from an integrated RF transceiver 113, but from different stand-alone RF transceiver / repeaters 111. As will be further explained in association with the preferred data transmission protocol, duplicative transmissions (*e.g.*, data transmissions received at more than one local gateway 110 originating from a single RF communication device) may be appropriately handled.

Significantly, the local gateways 110 may communicate with all DDMCS 100 RF communication devices. Since the local gateways 110 are permanently integrated with the WAN 130, the application server 160 can host application specific software which was typically hosted in an application specific local controller 10 as shown in FIG. 1. Of further significance, the data monitoring and control devices of the present invention need not be disposed in a permanent location as long as they remain within signal range of a system compatible RF communication device that subsequently is within signal range of a local gateway 110 interconnected through one or more networks to the application server 160. In this regard, small application specific transmitters compatible with the DDMCS 100 can be worn or carried about one's person or may be integrated into position detecting sensors as will be further described below. Of still further significance, the DDMCS 100 as illustrated in FIG. 2, provides a flexible access and control solution through virtually any suitably configured computing device in communication with the

WAN 130. As by way of example, a laptop computer 140 and / or a computer workstation 150 appropriately configured with suitable software may provide remote operator access to data collected via the DDMCS 100. In more robust embodiments, the laptop computer 140 and the computer workstation 150 may permit user entry of remote operative commands.

In one preferred embodiment of the DDCMS 100, an application server 160 collects, formats, and stores client specific data from each of the integrated RF transmitters 115, RF transceivers 113, and or RF transceiver / repeaters 111 for later retrieval or access from workstation 150 or laptop 140. In this regard, workstation 150 or laptop 140 can be used to access the stored information via a Web browser in a manner that is well known in the art. In another embodiment, the application server 160 may host application specific control system functions and replace the local controller 10 (see FIG. 1) by generating required control signals for appropriate distribution via WAN 130 and local gateways 110 to the system sensor / actuators 112. In a third embodiment, clients may elect for proprietary reasons to host control applications on their own WAN 130 connected workstation 150. In this regard, database 170 and application server 160 may act solely as data collection and reporting devices with the client workstation 150 generating control signals for the system.

It will be appreciated by those skilled in the art that the information transmitted and received by the RF communication devices of the present invention may be further integrated with other data transmission protocols for transmission across telecommunications and computer networks other than the WAN 130. In addition, it should be further appreciated that telecommunications and computer networks other than the WAN 130 can function as a transmission path between the communicatively coupled RF communication devices, the local gateways 110, and the application server 160.

Having generally described the architecture and operation of a DDCMS 100 in accordance with the present invention with regard to FIG. 2, reference is now made to FIG. 3, which presents a schematic diagram illustrating multiple residential systems that may be coupled to the RF communication devices of the DDCMS 100 of FIG. 2. In this regard, a residence 300 may be configured with a plurality of exemplary systems and

devices, such as but not limited to, a pet feeder 310, a HVAC system 312, an exterior lighting system 314, an interior lighting system 316, a security system 318, an irrigation system 320, a plurality of motorized window shades 322, a plurality of utility meters 324, as well as, a plurality of home appliances 326. As is illustrated in FIG. 3, each of the aforementioned systems and or devices may be integrated with one or more sensors 114 or alternatively one or more sensor / actuators 112, wherein each of the sensors 114 or sensor / actuators 112 are communicatively coupled with a RF communication device to permit data transmissions to and from the DDCMS 100 of FIG. 2.

As previously described and further illustrated in FIG. 2, a sensor 114 in configuration with a household appliance 326 may be configured to monitor one or more appliance related status parameters. The household appliance 326 related data may be communicated via a sensor 114a to a RF transmitter 115, which may be configured to receive the status parameter, encode the information, generate, and transmit a data signal transmission comprising the encoded status parameter and a transmitter identification. It will be appreciated that the appliance status parameters may include any or all of the following examples: an on / off status, a cycle selected status, a temperature, a time remaining for a particular cycle, *etc*. As illustrated in FIG. 3, a suitably situated and configured RF transceiver / repeater 111a within range of the RF transmitter 115 may be configured to receive a plurality of data signal transmissions from a plurality of compatibly configured RF communication devices. As illustrated in FIG. 3, the RF transceiver / repeater 111a may be a stand-alone device situated to receive data transmissions from throughout the residence 300. The RF transceiver / repeater 111a may be configured to receive the data signal transmission originating from the appliance 326. In accordance with a preferred data transmission protocol, the RF transceiver / repeater 111a may be configured to concatenate a repeater identification with the previous data signal information. In this way, a suitably configured application server 160 (FIG. 2) in communication with the WAN 130 (FIG. 2) may be provided RF transceiver / repeater 111 identification information, RF transmitter 115 identification information, and application specific data via the DDCMS 100.

By way of further example, a utility meter 324 (*e.g.*, a natural gas meter, an electric power meter, or a water meter) may be communicatively coupled with a sensor 114b to a RF transceiver 113g, which may be configured to receive at least one status parameter, encode the information, generate, and transmit a data signal transmission comprising the encoded status parameter and a transceiver identification. It will be appreciated that the utility meter status parameter may include a digital representation of the current usage of the related commodity (*e.g.*, kilowatt-hours in the case of an electric utility meter). As illustrated in FIG. 3, a suitably situated and configured RF transceiver / repeater 111a within range of the RF transceiver 113g may be configured to receive a plurality of data signal transmissions from a plurality of compatibly configured RF communication devices. The RF transceiver / repeater 111a may be configured to receive the data signal transmission originating from the utility meter 324. In accordance with a preferred data transmission protocol, the RF transceiver / repeater 111a may be configured to concatenate a repeater identification with the previous data signal information. In this way, a suitably configured application server 160 (FIG. 2) in communication with the WAN 130 (FIG. 2) may be provided RF transceiver / repeater 111a identification information, RF transceiver 113g identification information, and the current usage of the related commodity from the utility meter 324 via the DDCMS 100.

As is also illustrated in FIG. 3, one or more window shades 322 configured with a motorized mechanism for extending / retracting the shade(s) may be communicatively coupled with a sensor / actuator 112g to a RF transceiver / repeater 111b, which may be configured to receive at least one status parameter, encode the information, generate, and transmit a data signal transmission comprising the encoded status parameter and a transceiver identification in a monitoring or data collection mode. It will be appreciated that the window shade 322 status parameter may include a digital representation of the current position of the furthest panel of a multi-panel shade from a motorized mechanism. As illustrated in FIG. 3, a suitably situated and configured RF transceiver / repeater 111a within range of the RF transceiver / repeater 111b may be configured to receive a plurality of data signal transmissions from a plurality of compatibly configured RF communication devices. The RF transceiver / repeater 111a may be configured to receive

the data signal transmission originating from the window shades 322. In accordance with a preferred data transmission protocol, the RF transceiver / repeater 111a may be configured to concatenate a repeater identification with the previous data signal information. In this way, a suitably configured application server 160 (FIG. 2) in communication with the WAN 130 (FIG. 2) may be provided RF transceiver / repeater 111a identification information, RF transceiver / repeater 111b identification information, and the current usage of the related commodity from the utility meter 324 via the DDCMS 100.

It is significant to note that the transceiver / repeater 111b in communication with at least one sensor / actuator 112g may receive and communicate one or more command signal transmissions from a suitably configured computing device connected to the WAN 130 (*e.g.*, the application server 160, a laptop computer 140, a workstation computer 150, *etc.*) via the local gateway 110 (FIG. 2). In this way, appropriately configured software in a WAN 130 interconnected computing device can be used to remotely configure a plurality of appropriately integrated window shades 322.

As further illustrated in FIG. 3, an irrigation system controller 320 and or one or more individual sprinkler heads (not shown) may be communicatively coupled with a sensor / actuator 112f that is in further communication with a RF transceiver 113f. This combination may be configured to both send and receive a plurality of data signal and command signal transmissions via the DCCMS 100 of FIG. 2. It is significant to note that the diagram of FIG. 3 highlights the inherent flexibility of the signal path in a preferred architecture of the DCCMS 100. In this regard, the RF transceiver 113f may communicate and receive data and command signal transmissions via RF transceiver / repeater 111b or a stand-alone RF transceiver / repeater 111a. As with the previously introduced devices, the transceiver / repeater 113f may be configured to receive at least one status parameter from the associated sensor / actuator 112f, encode the information, and generate and transmit a data signal transmission comprising the encoded status parameter and a transceiver identification in a monitoring or data collection mode. It will be appreciated that the irrigation system 320 status parameter may include a digital representation of the rainwater in a rain gauge. As illustrated in FIG. 3, a suitably

situated and configured RF transceiver / repeater 111a and / or a suitably situated RF transceiver / repeater 111b within range of the RF transceiver 113f may be configured to receive a plurality of data signal transmissions from a plurality of compatibly configured RF communication devices. The RF transceiver / repeater 111b may be configured to receive the data signal transmission originating from the irrigation system 320. In accordance with a preferred data transmission protocol, the RF transceiver / repeater 111b may be configured to concatenate a repeater identification with the previous data signal information before forwarding the data signal transmission on to the stand-alone RF transceiver / repeater 111a.

It will be appreciated that either the stand-alone RF transceiver / repeater 111a or a local gateway 110 within the data transmission signal path may be configured to truncate a duplicative data transmission and / or a duplicative command signal transmission. In this way, both data signal transmissions and command signal transmissions may traverse the wireless infrastructure of the DDCMS 100 (FIG. 2) to implement a remote monitoring / control solution for home automation applications.

As also illustrated in FIG. 3, a security system 318, an interior lighting system 316, a HVAC system 312, and a pet feeder 310 may be associated via a sensor / actuator 112 in further communication with an associated RF transceiver 113, to the DCCMS 100. As is further illustrated in FIG. 3, any of the RF transceivers 113 or the RF transceiver / repeaters 111 may be configured such that the data transmission comprises a portion that identifies an Internet protocol (IP) address of a destination device. Those skilled in the art will appreciate that a local gateway 110 (FIG. 2) may be configured to simply forward the IP address or in the alternative, insert an appropriate IP address for the designated destination computing device. It is significant to note that the various systems and items enumerated in FIG. 3 are offered by way of example only.

Having described a number of exemplary residential applications in accordance with the present invention in FIG. 3, reference is now directed to FIGs. 4A through 4D, which present functional block diagrams of various exemplary sensor, sensor / actuator, and RF communication device combinations that may be used to implement the DCCMS 100 of FIG. 2. In this regard, reference is directed to FIG. 4A, which illustrates a RF

transmitter 115 in association with a sensor 114 in a combination generally denoted by reference numeral 400.

As illustrated in FIG. 4A sensor 114 may be communicatively coupled with the RF transmitter 115. The RF transmitter 115 may comprise a transmit controller 405, a data interface 410, a data controller 420, a transmitter identification 430a, and an antenna 440. As is shown in FIG. 4A, a data signal forwarded from the sensor 114 may be received at an input port of the data interface 410. The data interface 410 may be configured to receive the data signal. In those situations where the data interface has received an analog data signal, the data interface 410 may be configured to convert the analog signal into a digital signal before forwarding a digital representation of the data signal to the data controller 420.

Each transmitter unit in a DCCMS 100 (FIG. 2) may be configured with a unique identification code (*e.g.*, a transmitter identification number) 430a, that uniquely identifies the RF transmitter 115 to the various other devices within the DCCMS 100 (FIG. 2). The transmitter identification number 430a may be programmable, and implemented in the form of, for example, an EPROM. Alternatively, the transmitter identification number 430a may be set / configured through a series of dual inline package (DIP) switches. Additional implementations of the transmitter identification number 430a, whereby the number may be set / configured as desired, may be implemented consistent with the broad concepts of the present invention.

As illustrated in FIG. 4A, the data controller may be configured to receive both a data signal from the data interface 410 and the transmitter identification number 430a. As previously described, the data controller 410 may be configured to format (*e.g.*, concatenate) both data portions into a composite information signal. The composite information signal may be forwarded to a transmit controller 405 which may be configured to use any of a number of various data modulation schemes to transmit the encoded RF signal from the sensor 114. It will be appreciated that the transmit controller 405 may convert information from digital electronic form into a format, frequency, and voltage level suitable for transmission from antenna 440. As previously mentioned, the transmitter identification number is set for a given transmitter 320. When received by the

application server 160 (FIG. 2), the transmitter identification number 430a may be used to access a look-up table that identifies, for example, the residence, the system, and the particular parameter assigned to that particular transmitter. Additional information about the related system may also be provided within the lookup table, with particular functional codes associated with a corresponding condition or parameter, such as but not limited to, an appliance operating cycle, a power on / off status, a temperature, a position, and / or any other information that may be deemed appropriate or useful under the circumstances or implementation of the particular system.

Reference is directed to FIG. 4B, which illustrates a RF transceiver 113 in association with a sensor 114 in a combination generally denoted by reference numeral 402. As illustrated in FIG. 4B sensor 114 may be communicatively coupled with the RF transceiver 113. The RF transceiver 113 may comprise a transceiver controller 460, a data interface 410, a data controller 420, a transceiver identification 430b, and an antenna 440. As is shown in FIG. 4B, a data signal forwarded from the sensor 114 may be received at an input port of the data interface 410. The data interface 410 may be configured to receive the data signal. In those situations where the data interface has received an analog data signal, the data interface 410 may be configured to convert the analog signal into a digital signal before forwarding a digital representation of the data signal to the data controller 420.

In accordance with a preferred embodiment, each transceiver 113 unit in a DCCMS 100 (FIG. 2) may be configured with a unique identification code (*e.g.*, a transceiver identification number) 430b, that uniquely identifies the RF transceiver 113 to the various devices within the DCCMS 100 (FIG. 2). The transceiver identification number 430b may be programmable, and implemented in the form of, for example, an EPROM. Alternatively, the transceiver identification number 430b may be set / configured through a series of dual inline package (DIP) switches. Additional implementations of the transceiver identification number 430b, whereby the number may be set / configured as desired, may be implemented consistent with the broad concepts of the present invention.

As illustrated in FIG. 4B, the data controller 420 may be configured to receive both a data signal from the data interface 410 and the transceiver identification number 430b. As is also illustrated in FIG. 4B, the data controller 420 may also receive one or more data signals from other RF communication devices. As previously described, the data controller 410 may be configured to format (*e.g.*, concatenate) both data signal portions originating at the transceiver 113 into a composite information signal which may also include data information from other closely located RF communication devices used in the DCCMS 100. The composite information signal may be forwarded to a transceiver controller 460 which may be configured to use any of a number of various data modulation schemes to transmit the encoded RF data signal from the sensor(s) 114 and / or the closely located sensor / actuators 112 (FIG. 2). It will be appreciated that the transceiver controller 460 may convert information from digital electronic form into a format, frequency, and voltage level suitable for transmission from the antenna 440. As previously mentioned with respect to the RF transmitter of FIG. 4A, the transceiver identification number 430b is set for a given transceiver 113. When received by the application server 160 (FIG. 2), the transceiver identification number 430b may be used to access a look-up table that identifies, for example, the residence, the system, and the particular parameter assigned to that particular transceiver. Additional information about the related system may also be provided within the lookup table, with particular functional codes associated with a corresponding condition or parameter, such as but not limited to, an appliance operating cycle, a power on / off status, a temperature, a position, and / or any other information that may be deemed appropriate or useful under the circumstances or implementation of the particular system. As will be explained in association with the RF transceiver / repeater 111 of FIG. 4D, the transceiver 113 may be configured to receive an forward command information either using a unique RF or in the preferred embodiment a time interleaved packet based communication technique.

Having generally described the architecture and operation of the combination of a RF transceiver 113 and a sensor 114 in a DCCMS 100 (FIG. 2) in accordance with the present invention as illustrated in FIG. 4B, reference is directed to FIG. 4C, which presents a functional block diagram of a RF transceiver 113 in association with a sensor /

actuator 112. As illustrated in FIG. 4C sensor / actuator 112 may be communicatively coupled with the RF transceiver 113. The RF transceiver 113 may comprise a transceiver controller 460, a data interface 410, a data controller 420, a transceiver identification 430b, and an antenna 440. As is shown in FIG. 4C, a data signal forwarded from the sensor / actuator 112 may be received at an input / output port of the data interface 410. The data interface 410 may be configured to receive the data signal and transmit a command signal. In those situations where the data interface has received an analog data signal, the data interface 410 may be configured to convert the analog signal into a digital signal before forwarding a digital representation of the data signal to the data controller 420. Similarly, when the data controller 420 forwards a digital representation of a command signal, the data interface 410 may be configured to translate the digital command signal into an analog voltage suitable to drive the actuator portion of the sensor actuator 112.

In accordance with a preferred embodiment, each RF transceiver 113 unit in a DCCMS 100 (FIG. 2) may be configured with a unique identification code (*e.g.*, a transceiver identification number) 430b, that uniquely identifies the RF transceiver 113 to the various devices within the DCCMS 100 (FIG. 2). As previously described with respect to the device combinations of FIGs. 4A and 4B, the transceiver identification number 430b may be set / configured as desired within the broad concepts of the present invention.

As illustrated in FIG. 4C, the data controller 420 may be configured to receive both a data signal from the data interface 410 and the transceiver identification number 430b. As is also illustrated in FIG. 4C, the data controller 420 may also receive one or more data signals from other RF communication devices. As previously described, the data controller 410 may be configured to format (*e.g.*, concatenate) both data signal portions originating at the RF transceiver 113 into a composite information signal which may also include data information from other closely located RF communication devices used in the DCCMS 100. The composite information signal may be forwarded to a transceiver controller 460 which may be configured to use any of a number of various data modulation schemes to transmit the encoded RF data signal from the sensor /

actuator 112 and or the closely located sensor / actuators 112 or sensors 114 of nearby systems (FIG. 2). It will be appreciated that the transceiver controller 460 may convert information from digital electronic form into a format, frequency, and voltage level suitable for transmission from the antenna 440. As previously described with respect to the RF transmitter of FIG. 4A and the RF transceiver of FIG. 4B, the transceiver identification number 430b is set for a given transceiver 113 and may be used to identify a host of information particularized to the respective RF transceiver 113. As will be explained in association with the RF transceiver / repeater 111 of FIG. 4D, the RF transceiver 113 may be configured to receive and forward command information either using a unique RF or in the preferred embodiment a time interleaved packet based communication technique.

Having generally described the architecture and operation of the combination of a RF transceiver 113 and a sensor / actuator 112 as may be used in a DCCMS 100 (FIG. 2) as illustrated in FIG. 4C, reference is directed to FIG. 4D, which presents a functional block diagram of a RF transceiver / repeater 111 in association with a sensor / actuator 112. Reference is now made to FIG. 4D, which is a block diagram similar to that illustrated in FIGs. 4A through 4C, but illustrating a RF transceiver / repeater 111 that is integrated with a sensor / actuator 112. In this illustration, the data interface 410 is shown with a single input from sensor / actuator 112. It is easy to envision a system that may include multiple sensor inputs. By way of example, a common home heating and cooling (*i.e.*, a HVAC) system 312 (FIG. 3) might be integrated with the present invention. The HVAC system 312 (FIG. 3) may include multiple data interface inputs from multiple sensors. A home thermostat control connected with the HVAC system 312 could be integrated with a sensor 114 that reports the position of a manually adjusted temperature control (*i.e.*, a temperature set value), as well as, a sensor 114 integrated with a thermister to report an ambient temperature. The condition of related parameters can be input to the data interface 410 along with the condition of the HVAC system 312 on / off switch, and the climate control mode selected (*i.e.*, heat, fan, or AC). In addition, depending upon the specific implementation, other system parameters may be provided to the data interface 410 as well.

The addition of the sensor / actuator 112 to the assembly permits the data controller 420 to apply particularized and encoded control signals to the manual temperature control for the temperature set point, the climate control mode switch, and the system on / off switch. In this way, a remote workstation 150 or laptop 140 with WAN 130 access (see FIG. 2) could control a home heating system from a remote location. Furthermore, an application server 160 in accordance with the DCCMS 100 of FIG. 2 may be suitably configured to automatically control the HVAC system 312 (FIG. 3).

Again, each of these various input signals are routed to the data interface 410, which provides the information to a data controller 420. The data controller 420 may utilize a look-up table 425 to access unique function codes that are communicated in data packet 450c, along with a transceiver identification code 430b via RF, to a local gateway 110 and further onto a WAN 130 (FIG. 2). In general, the operation of the RF transceiver / repeater 111 will be similar to that described for a RF transmitter 115 and a RF transceiver 113, as previously illustrated in FIGs. 4A through 4C. It is significant to note that data packet 450c will include a concatenation of the individual function codes selected for each of the aforementioned input parameters, as well as, a data stream 450b that may be received from other closely located RF transmitters 115 and RF transceivers 113. As previously described, the RF transceiver / repeater 111 may comprise a data controller 420 configured to generate a composite data stream in a transmit mode, as well as, a composite command stream in a receive mode that may be suitably processed and transmitted. As by way of example, the application server 160 may provide the client workstation 150 with a Web page display that models a common home thermostat. As previously described, either the application server 160 or the client workstation 150 may include application software that would permit a user with access to the computing devices via the WAN 130 to remotely adjust the controls on a residential HVAC system 312 by adjusting related functional controls on a graphical user interface (GUI) updated with feedback from the DCCMS 100 (FIG. 2).

More specifically, RF transceiver / repeater 111 is shown with four specific parameters related to four specific function codes as illustrated in look-up table 425. In

this regard, the sensor / actuator 112 (one sensor shown for simplicity) inputs a data signal to the data interface 410. The data controller 420 receives an input from the data interface 410 that it may associate with a specific function code as shown in look-up table 425. The data controller 420 may assemble a data packet 450c by concatenating received data packet 450b with its own transceiver identification code 430b and its own specific function codes. The data packet 450c may then be converted by the transceiver / repeater controller 465 for transmission via antenna 440 to either a stand-alone RF transceiver / repeater 111 as shown in FIG. 2, or alternatively, to a suitably configured local gateway 110.

It will be appreciated by persons skilled in the art that the data interface 410 and the data controller 420 may be uniquely configured to interface with specialized sensor / actuator(s) 112. These circuits, therefore, may differ from RF transceiver / repeater 111 to RF transceiver / repeater 111, depending upon the remote system that is monitored and the related actuators to be controlled. However, in the preferred embodiment, the data interface 410 and the data controller 420 are pre-configured such that function code interpretation may be performed via a configuration smart application server 160 or a database server 170 in communication with the RF transceiver / repeater 111 via the DCCMS 100 of FIG. 2. In this regard, the implementation of the data interface 410 and the data controller 420 will be understood by persons skilled in the art, and need not be described herein to appreciate the concepts and teachings of the present invention.

In addition, to the RF communication device - sensor / actuator combinations illustrated and described hereinabove with respect to FIGs. 4A through 4D, a mobile transceiver (not shown) in accordance with the present invention is also contemplated. The mobile transceiver may take the shape of a commonly recognized transmitter associated with automobile access functions. For example, a personal mobile transceiver may comprise a plurality of transmit pushbuttons with each assigned to a particular functional code associated with the party assigned to the personal mobile transceiver. By way of example, an emergency call function may be assigned to a first transmit pushbutton. As previously described, the personal mobile transceiver may be configured to transmit an encoded message identifying the party assigned to the transceiver. Upon

receiving the incoming message, an application server 160 in communication with the personal mobile transceiver via a DCCMS 100 of FIG. 2 may identify the party and that the first transmit pushbutton has been depressed. The application server 160 may prompt its own look-up table or an associated database server 170 for an interpretive match for the first pushbutton on that particular party's personal mobile transceiver. Furthermore, additional codes may be provided as necessary to accommodate additional functions or features for a given transceiver. Thus, in operation, a user may depress the emergency pushbutton, which is detected by the data interface 410. The data interface 410 may communicate the input to a data controller 420 which may then use the information pertaining to the emergency pushbutton to access a look-up table 425 to retrieve a code that is uniquely assigned to the pushbutton for that particular individual. The data formatter 420 may also retrieve the pre-configured transceiver identification number 430b in configuring a data packet 450c for communication via RF signals to a nearby RF transceiver 113.

It will be appreciated by persons skilled in the art that the various RF communication devices illustrated and described in relation to the functional block diagrams of FIGs. 4A through 4D may be configured with a number of optional power supply configurations. For example, a personal mobile transceiver may be powered by a replaceable battery. Similarly, a stand-alone RF transceiver / repeater 111 may be powered by a replaceable battery that may be supplemented and or periodically charged via a solar panel. These power supply circuits, therefore, may differ from RF communication device to RF communication device depending upon the remote system monitored, the related actuators to be controlled, the environment, and the quality of service level required. Those skilled in the art will appreciate and understand how to meet the power requirements of the various RF communication devices associated with the DCCMS 100 of the present invention. As a result, it is not necessary to further describe a power supply suitable for each RF communication device and each application in order to appreciate the concepts and teachings of the present invention.

Having illustrated and described the operation of the various combinations of RF communication devices with the various sensors 114 and sensor / actuators 112 consistent

with the present invention, reference is now made to FIG. 5, which is a block diagram further illustrating a local gateway 110 within the DCCMS 100 of FIG. 2. As illustrated in FIG. 5, a local gateway 110 may comprise an antenna 440, a RF transceiver 113, a central processing unit (CPU) 522, a memory 524, a network card 526, a digital subscriber line (DSL) modem 528, an integrated services digital network (ISDN) interface card 530, as well as other components not illustrated in FIG. 5, capable of enabling a terminal control protocol / Internet protocol (TCP/IP) connection to the WAN 130.

As illustrated in FIG. 5, the RF transceiver 113 may be configured to receive incoming RF signal transmissions via the antenna 440. Each of the incoming RF signal transmissions may be consistently formatted in the convention previously described. The local gateway 110 may be configured such that the memory 524 includes a look-up table 525 that may assist in identifying the various remote and intermediate RF communication devices used in generating and transmitting the received data transmission as illustrated in memory sectors 527 and 529 herein labeled, "Identify Remote Transceiver" and "Identify Intermediate Transceiver," respectively. Programmed or recognized codes within the memory 524 may also be provided and configured for controlling the operation of a CPU 522 to carry out the various functions that are orchestrated and / or controlled by the local gateway 110. For example, the memory 524 may include program code for controlling the operation of the CPU 522 to evaluate an incoming data packet to determine what action needs to be taken. In this regard, one or more look-up tables 525 may also be stored within the memory 524 to assist in this process. Furthermore, the memory 524 may be configured with program code configured to identify a remote RF transceiver 527 or identify an intermediate RF transceiver 529. Function codes, RF transmitter and or RF transceiver identification numbers 430a, 430b, may all be stored with associated information within the look-up tables 525.

Thus, one look-up table 525 may be provided to associate transceiver identification numbers 430b (FIGs. 4C, 4D) with a particular user. Another look-up table 525 may be used to associate function codes 425 (FIG. 4D) with the interpretation thereof. For example, a unique code may be associated by a look-up table 525 to identify

functions such as test, temperature, smoke alarm active, security system breach, *etc.* In connection with the lookup table(s) 525, the memory 524 may also include a plurality of code segments that are executed by the CPU 522, which may in large part control operation of the gateway 110. For example, a first data packet segment 450c may be provided to access a first lookup table to determine the identity of the RF transceiver 113, which transmitted the received message. A second code segment 450c' (not shown) may be provided to access a second lookup table to determine the proximate location of the message generating RF transceiver 113, by identifying the RF transceiver 113 that relayed the message. A third code segment 450c'' (not shown) may be provided to identify the content of the message transmitted. Namely, is it a fire alarm, a security alarm, an emergency request by a person, a temperature control setting, *etc.* Consistent with the invention, additional, fewer, or different code segments may be provided to carryout different functional operations and data signal transfers throughout the DCCMS 100 (FIG. 2) of the present invention.

The local gateway 110 may also include one or more mechanisms to facilitate network based communication with remote computing devices. For example, the gateway 110 may include a network card 526, which may allow the gateway 110 to communicate across a local area network to a network server, which in turn may contain a backup gateway 110 (not shown) to the WAN 130 (FIG. 2). Alternatively, the local gateway 110 may contain a DSL modem 528, which may be configured to provide a link to a remote computing system, by way of the PSTN 12 (FIG. 1). In yet another alternative, the local gateway 110 may include an ISDN card 530 configured to communicate via an ISDN connection with a remote system. Other communication interfaces may be provided as well to serve as primary and or backup links to the WAN 130 or to local area networks that might serve to permit local monitoring of gateway 110 health and data packet control.

Having described the physical layer of a DCCMS 100 (FIG. 2) consistent with the present invention, reference is now made to FIG. 6, which describes a data structure of messages that may be sent and received via the DCCMS 100. In this regard, a standard message may comprise a "to" address; a "from" address; a packet number; a maximum

packet number, a packet length; a command portion; a data portion; a packet check sum (high byte); and a packet check sum (low byte). As illustrated in the message structure table of FIG. 6, the "to" address or message destination may comprise from 1 to 6 bytes. The "from" address or message source device may be coded in a full 6 byte designator. Bytes 11 through 13 may be used by the system to concatenate messages of packet lengths greater than 256 bytes. Byte 14 may comprise a command byte. Byte 14 may be used in conjunction with bytes 15 through 30 to communicate information as required by DCCMS 100 specific commands. Bytes 31 and 32 may comprise packet check sum bytes. The packet check sum bytes may be used by the system to indicate when system messages are received with errors. It is significant to note that bytes 31 and 32 may be shifted in the message to replace bytes 15 and 16 for commands that require only one byte. The order of appearance of specific information within the message protocol of FIG. 6 generally remains fixed although the byte position number in individual message transmissions may vary due to scalability of the "to" address, the command byte, and scalability of the data portion of the message structure.

Having described the general message structure of a message that may be sent via the DCCMS 100 of the present invention, reference is directed to FIG. 7, which illustrates three sample messages. The first message illustrates the broadcast of an emergency message "FF" from a central server with an address "0012345678" to a personal transceiver with an address of "FF."

The second message reveals how the first message might be sent to a RF transceiver that functions as a repeater. In this manner, emergency message "FF" from a central server with address "0012345678" is first sent to transceiver "F0." The second message, further contains additional command data "A000123456" that may be used by the system to identify further transceivers to send the signal through on the way to the destination device.

The third message illustrated on FIG. 7 reveals how the message protocol of the present invention may be used to "ping" a remote RF transceiver 113 (FIG. 2) in order to determine transceiver health. In this manner, source unit "E112345678" originates a ping request by sending command "08" to a transceiver identified as "A012345678." The

response to the ping request can be as simple as reversing the "to address" and the "from address" of the command, such that, a healthy transceiver will send a ping message back to the originating device. The system of the present invention may be configured to expect a return ping within a specific time period. Operators of the present invention could use the delay between the ping request and the ping response to model system loads and to determine if specific DCCMS 100 parameters might be adequately monitored and controlled with the expected feedback transmission delay of the system.

Reference is now made to FIG. 8, which is a diagram illustrating WAN 130 connectivity in a DCCMS 100 (FIG. 2) constructed in accordance with the invention. In this regard, the local gateway 110 may be configured to transmit control signals and receive data signals using the open data packet protocol as previously described. The local gateway 110 is preferably interconnected permanently on the WAN 130 and configured to translate received data signals for WAN 130 transfer via TCP/IP. An application server 160 configured with web applications and client specific applications as required may be communicatively coupled to the WAN 130 via router 810 and further protected and buffered by firewall 820. Consistent with the concepts and teachings of the present invention, the application server 160 may be assisted in its task of storing and making available client specific data by a database server 170.

As further illustrated in FIG. 8, a client workstation 150 configured with a Web browser may be connected to the WAN 130 at a client premise. Alternatively, clients may access the WAN 130 via a remote laptop 140 or other computing devices (not shown) configured with a compatible Web browser or other user interface. In this way, the application server 160 may provide client specific data upon demand.

Having described the DCCMS 100 of the present invention with regard to FIG. 2 and further described WAN 130 connectivity with regard to FIG. 8, reference is now made to FIG. 9, which illustrates a specific home automation application consistent with application of the invention. More specifically, FIG. 9 illustrates the integration of the DCCMS 100 with an irrigation control system 900. For simplicity, controlled area 910 is represented by a single rain gauge 913 and a single related sprinkler head 917. It is easy to see that such a system could be modified and expanded to monitor and control any of a

number of separate irrigation systems, irrigation sprinkler heads, or a multiple zone irrigation system controller integrated with the DCCMS 100 of the present invention.

As illustrated in FIG. 9, the controlled area 910 is configured with a rain gauge 913 integrated with sensor 114 wherein a measure of rainfall and applied water to the adjacent area may be converted to a voltage signal that may be transmitted via functional codes by RF transmitter 115 along with a related transmitter identification code 430a (FIG. 4A) in a manner previously described. As further illustrated in FIG. 9, a stand-alone RF transceiver / repeater 111 may further process and transmit the encoded data to the local gateway 110, which may translate the data packet information into TCP/IP format for transfer across the WAN 130 to the various computing devices associated with the WAN 130. The application server 130 may collect and format the rain gauge 913 data for viewing or retrieval upon client request in a manner previously described. Additionally, the application server 160 may be configured to communicate a command signal to operate sprinkler head 917 by opening water supply valve 916 integrated with a sensor / actuator 112 by sending a control signal to RF transceiver 113, per a client directed water application control schedule. Alternatively, a customer workstation 150 or a laptop 140 associated with the WAN 130 may periodically download and review the rain gauge 913 data and may initiate an operator directed control signal. It is significant to note that the customer workstation 150 could initiate a change in its own application software, or with the proper access capabilities may modify various system parameters associated with the irrigation system 900. The general operation and interconnectivity of the application server 160 and an associated database server 170 function as previously illustrated and described with regard to FIGs. 2 and 8. It is significant to note however that the application server 160 may contain a suitably configured software interface (not shown) along with associated applications necessary to support a remote access and controllable residential irrigation system 900. Those skilled in the art will appreciate how to develop and implement software interfaces and modules to enable the various desired functions associated with each particular residential application. Specific software interfaces and other applications need not be described herein to appreciate the concepts

and teachings of the DCCMS 100 of the present invention and the integration thereof with a particular home automation system.

Having described the integration of a DCCMS 100 of the present invention with a residential irrigation system 900 with regard to FIG. 9, reference is now made to FIG. 10, which illustrates a second specific home automation application consistent with the present invention. As illustrated FIG. 10, a remote utility meter monitoring system 1000 may be integrated with the DCCMS 100 of FIG. 2. The remote utility monitoring system 1000 may comprise the DCCMS 100 infrastructure as described hereinabove with regard to FIG. 2 and a utility meter subsystem 1010. As further illustrated in FIG. 10, the utility meter subsystem 1010 may comprise a utility meter 1013, an appropriately integrated sensor 114 wherein the utility meter 1013 operational status and current utility meter usage total is transmitted via functional codes to a RF transmitter 115. The RF transmitter 115, as previously introduced and described hereinabove, may be configured to forward the related functional codes along with a transmitter identification code 430a in a formatted data packet. As also illustrated in FIG. 10, a stand-alone RF transceiver / repeater 111 may receive, process, and transmit the encoded data and the RF communication device identifiers to the local gateway 110 which translates the data packet information into TCP/IP format for transfer across the WAN 130 to the application server 160. The application server 160 may be configured to collect and format the utility meter information for viewing and or retrieval upon client request in a manner previously described.

Having illustrated specific applications using the DCCMS 100 of the present invention in exemplary home automation systems, reference is now made to FIG. 11 which illustrates a residential monitoring and control service system 1100. In accordance with a preferred embodiment, the residential monitoring and control service system 1100 may monitor and control remote data points associated with a plurality of home automation systems. As illustrated in FIG. 11, a plurality of home automation applications herein identified by way of non-limiting examples as an irrigation control application 1120, a lighting control application 1130, and a HVAC control application

1140 may be packaged as by way of one or more software applications to provide a residential monitor / remote control service 1110.

As further illustrated in FIG. 11, an application server 160 along with an associated database server 170 may be in communication with a plurality of systems 1102 via the DCCMS 100 infrastructure. Each of the plurality of systems 1102a, 1102b, . . ., 1102x may be associated with a residential automation application such as those previously identified with regard to FIG. 3. As shown in FIG. 11, one or more clients of the residential monitor / remote control service 1110 may elect to subscribe to a plurality of services associated with appropriately integrated sensors 114, sensor / actuators 112, and RF communication devices as previously described.

For example, the controlled area 910 of the irrigation control system 900 shown in FIG. 9, the remote utility meter subsystem 1010 illustrated in FIG. 10, and other home automation systems and or subsystems as desired may be monitored and remotely controlled (where required) by an appropriately configured application server 160. In a manner previously described herein, the application server 160 collects and processes data information transferred and sent over the WAN 130 by local gateways 110 coupled via RF communication devices associated with a plurality of sensors 114 and sensor / actuators 112 appropriately integrated as required to monitor and or control the various systems 1102a, 1102b, . . ., 1102x. For simplicity, FIG. 11 shows each of the systems operated by a singular application server 130 with its own dedicated local gateway 110. It will be appreciated by those skilled in the art that small-scale systems jointly located within a geographic area served by a DCCMS 100 in accordance with the present invention may be configured to share the RF transceiver / repeater 111 and local gateway 110 infrastructure of a previously installed local system.

Although there will necessarily be some initial configuration to such a system, ultimately, data may be displayed to a client operator accessing the information over the WAN 130 in a variety of manners. Referring to FIG. 12A, one possible GUI display is illustrated. Specifically, for a given client household which may be indicated by an address, alphanumeric titles for the various systems, devices, and appliances that have RF communication devices and appropriately configured sensors and actuators associated

with them may be displayed. Likewise, an appropriate status, parameter reading, or operational control setting may be displayed next to the device identifier. By way of illustration, HVAC system 312 (FIG. 3) settings may be displayed such as an operating mode, a temperature setting, and a temperature reading (denoted as temperature actual). For any identifier that may be user controlled, a drop down menu may be provided to allow ready access and control. For example, consider a user wishing to change the mode of a thermostat. The user may initiate this change by clicking on an arrow. The screen may then present a drop down menu as illustrated in FIG. 12B. This menu may list all the options available to the user, such as air/auto, air/fan, heat/auto, heat/fan, and off. The user may simply select the setting of choice by using a mouse or other input device. This information may then be taken and routed to the appropriate thermostat at the appropriate client household as previously described hereinabove.

As further illustrated in the sample GUIs illustrated in FIGs. 12A and 12B, multiple home automation systems may be displayed simultaneously in accordance with a client driven package of home automation services. Those skilled in the art will appreciate that alternative methods and arrangements of the various data information and controls may be provided without varying from the teachings and concepts of the present invention. For example, each specific home automation application may correspond to an associated graphical user interface. In a related manner, individual clients may have a need or a desire to customize the look and feel of a personal interface.

It will be further appreciated that what has been described herein is a very top-level illustration of a system constructed in accordance with the DCCMS 100 of the present invention. In accordance with the invention, a variety of household devices and appliances may be monitored and controlled from a remote location via WAN 130 interconnected computing devices. It is significant to note that the WAN 130 may take the form of a private Intranet or as in the preferred embodiment may comprise the public access network commonly known as the Internet. The data and command transmissions may be transmitted and received at a WAN 130 interconnected local gateway 110, which may be in communication with a series of RF communication devices. The data and

command transmissions may be relayed via the various RF communication devices as required until they reach a designated residential destination or the local gateway 110.

It is significant to note that one or more specific types of RF transceivers may be integrated within the DCCMS 100 of the present invention. For example, one RF transceiver that may be used is the TR1000, manufactured by RF Monolithics, Inc.

As is known, the TR1000 hybrid transceiver is well suited for short range, wireless data applications where robust operation, small size, low power consumption, and low-cost are desired. All critical RF functions are contained within the single hybrid chip, simplifying circuit design and accelerating the design-in process. The receiver section of the TR1000 is sensitive and stable. A wide dynamic range log detector, in combination with digital automatic gain control (AGC) provide robust performance in the presence of channel noise or interference. Two stages of surface acoustic wave (SAW) filtering provide excellent receiver out-of-band rejection. The transmitter includes provisions for both on-off keyed (OOK) and amplitude-shift key (ASK) modulation. The transmitter employs SAW filtering to suppress output harmonics, for compliance with FCC and other regulations.

Additional details of the TR1000 transceiver need not be described herein, because the present invention is not limited by the particular choice of transceiver. Indeed, numerous RF transceivers may be implemented in accordance with the teachings of the present invention. Such other transceivers may include other 900 MHz transceivers, as well as transceivers at other frequencies. In addition, infrared, ultrasonic, and other types of transceivers may be employed, consistent with the broad scope of the present invention. Further details of the TR1000 transceiver may be obtained through data sheets, application notes, design guides (*e.g.*, the "ASH Transceiver Designers Guide"), and other publications known those skilled in the art.

In addition to the information described above, it will be appreciated that the transceivers and repeaters may also relay digitized voice information. That is, digitized voice information may comprise a portion of the data payload. Thus, certain devices may be configured to be operated from voice (*e.g.*, speech recognition), and can receive the necessary speech data from the data payload. Furthermore, both pre-recorded and real-

time public safety broadcasts, such as but not limited to, weather related warnings, public emergency notices, local law enforcement announcements, and the like, may be broadcast via a DCCMS 100 in accordance with the present invention. For example, a pre-recorded hurricane evacuation message may be triggered by a suitable command broadcast via the DCCMS 100 and received at a residential device suitable configured to play an associated copy of the message. In more robust configurations, a local law enforcement / public interest message may be sent in an encoded format via the DCCMS 100 and reassembled in an appropriately configured residential device whereby the message may be reconstructed in near real-time. The one or more residential devices may be configured to override current intercoms and or other residential devices configured with audio capability. It will be appreciated that each of the various types of messages may be identified with an associated priority level. It will be further appreciated that the corresponding public service message may be handled in a different manner in accordance with the designated priority level.

The foregoing description has illustrated certain fundamental concepts of the invention as they relate to the specific home automation applications referenced by example hereinabove. It is significant to note that other additions and / or modifications may be made consistent with the inventive concepts. For example, the RF transmitters 115 illustrated in FIGs. 2 and 4A and implemented in a control system as illustrated in FIG. 10 may be adapted to monitor the current status of an electric, water, or natural gas utility meter. RF transmitters 115 might further be used to monitor and report actual operational hours on motorized equipment or any other apparatus that must be serviced or monitored based on an actual run-time schedule.

The RF transceivers 113 of the current invention may be adapted to monitor and apply control signals in an unlimited number of applications. By way of example only, RF transceivers 113 consistent with the teachings and concepts of the DCCMS 100 of the present invention can be adapted for use with consumer electronics, as well as, for use with a host of residential appliances and devices to provide a flexible home automation and security system.

In a geographic area appropriately networked with permanently located RF transceiver / repeaters 111 consistent with the invention, personal mobile transmitters consistent with the invention can be used to initiate communication with family members, neighbors, and or emergency response personnel.

The foregoing description has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Obvious modifications or variations are possible in light of the above teachings. For example, it should be appreciated that, in some implementations, the transceiver identification number 430b is not necessary to identify the location of the transceiver. Indeed, in implementations where the transceiver is permanently integrated into an alarm sensor other stationary device within a system, then the control system application server 160 and or the local gateway 110 may be configured to identify the transmitter location by the transmitter identification number alone. It will be appreciated that, in embodiments that do not utilize RF transceiver / repeaters 111, the RF transmitters 115 and / or RF transceivers 113 may be configured to transmit at a higher power level, in order to effectively communicate with the local gateway 110.

The embodiment or embodiments discussed were chosen and described to illustrate the principles of the invention and its practical application to enable one of ordinary skill in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. All such modifications and variations are within the scope of the invention as determined by the appended claims when interpreted in accordance with the breadth to which they are fairly and legally entitled.